US009237547B1

(12) **United States Patent**
Antoun et al.

(10) **Patent No.: US 9,237,547 B1**
(45) **Date of Patent: Jan. 12, 2016**

(54) **MANAGEMENT OF CDMA REFERENCE CELL IDENTIFIERS IN AN LTE NETWORK**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 333 days.

(21) Appl. No.: **13/965,493**

(22) Filed: **Aug. 13, 2013**

(51) **Int. Cl.**
H04W 64/00 (2009.01)

(52) **U.S. Cl.**
CPC ***H04W 64/003*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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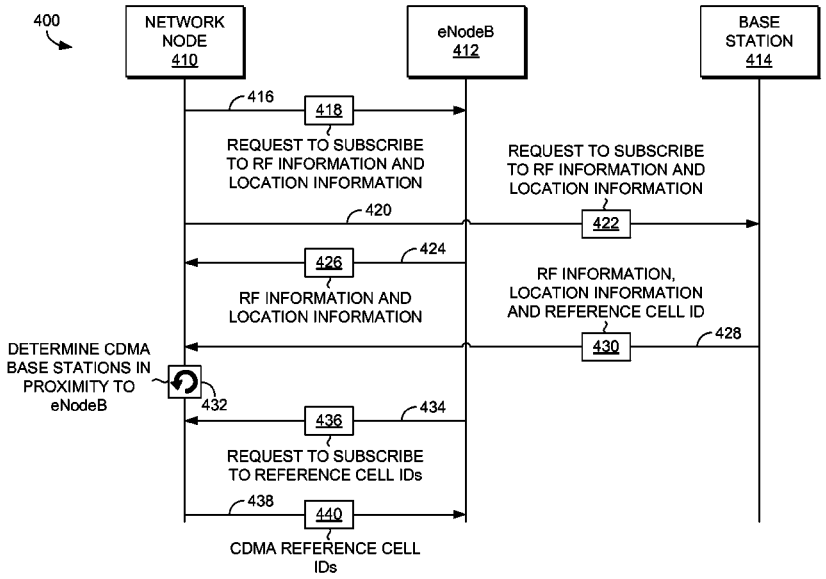
(57) **ABSTRACT**

A method, system, and medium are provided for managing CDMA reference cell identifiers (IDs) in a long-term-evolution (LTE) network using Session Initiation Protocol (SIP). A network node subscribes to RF coverage information and location information of eNodeBs and CDMA base stations within the network. After receiving this information from the eNodeBs and the CDMA base stations, the network node uses the information to determine CDMA base stations that are in proximity to each eNodeB. The eNodeBs in the network subscribe to CDMA reference cell IDs of those CDMA base stations that have been determined by the network node to be in proximity to the respective eNodeB. After receiving the CDMA reference cell IDs from the network node, the eNodeB utilizes the received information to select a CDMA base station to utilize when a network customer's UE requires circuit-switched services.

15 Claims, 6 Drawing Sheets



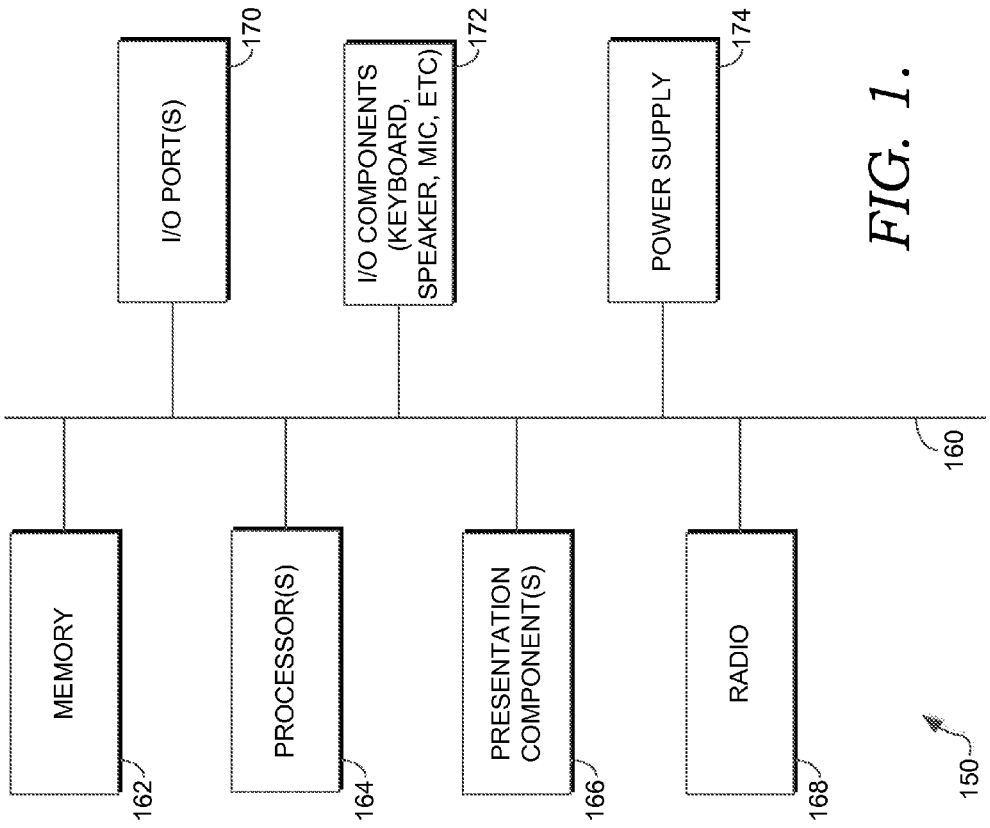

I/O PORT(S)
170
I/O COMPONENTS (KEYBOARD, SPEAKER, MIC, ETC)
172
POWER SUPPLY
174
160
MEMORY
162
PROCESSOR(S)
164
PRESENTATION COMPONENT(S)
166
RADIO
168
150

FIG. 1.

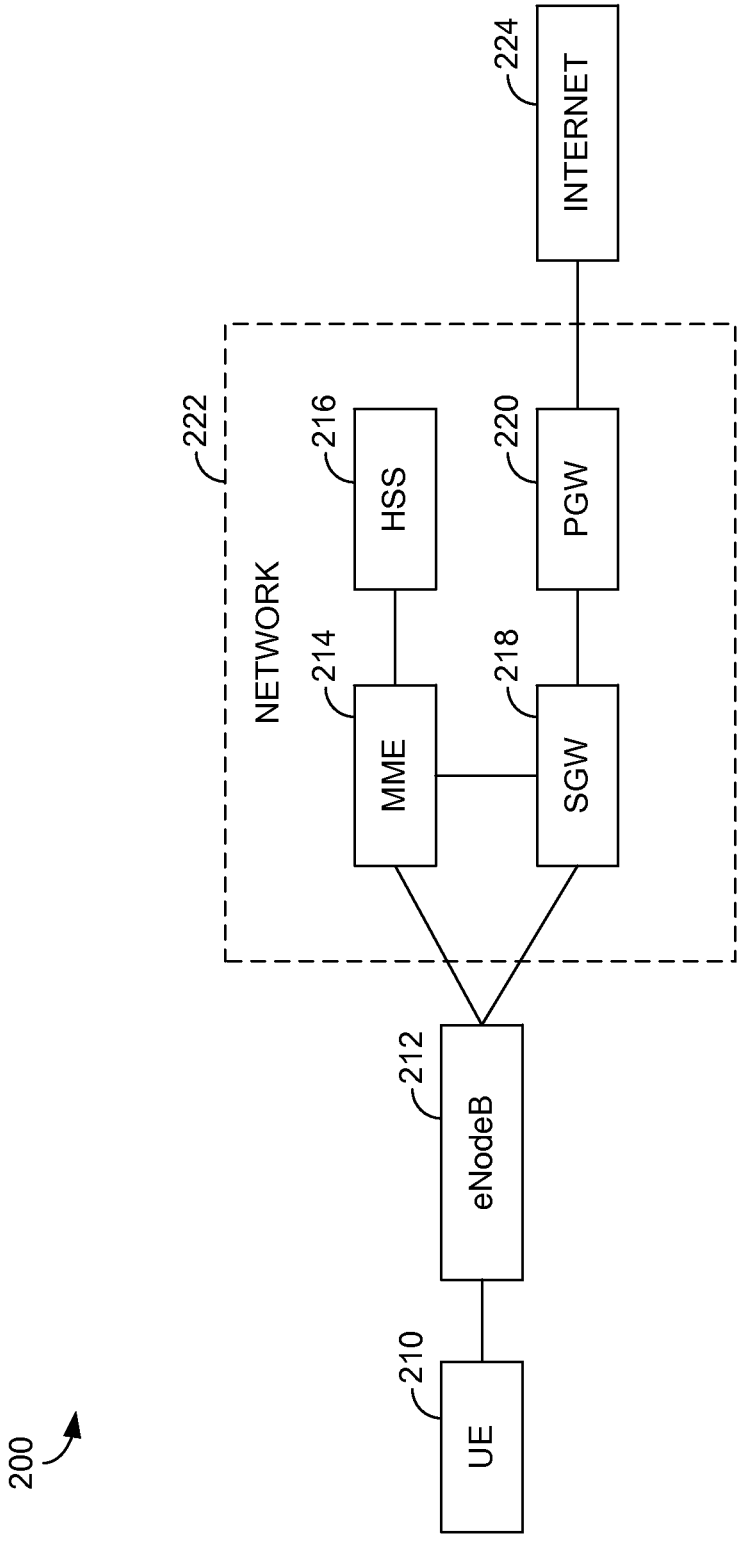

200
UE
210
eNodeB
212
MME
214
HSS
216
SGW
218
PGW
220
NETWORK
222
INTERNET
224

FIG. 2.

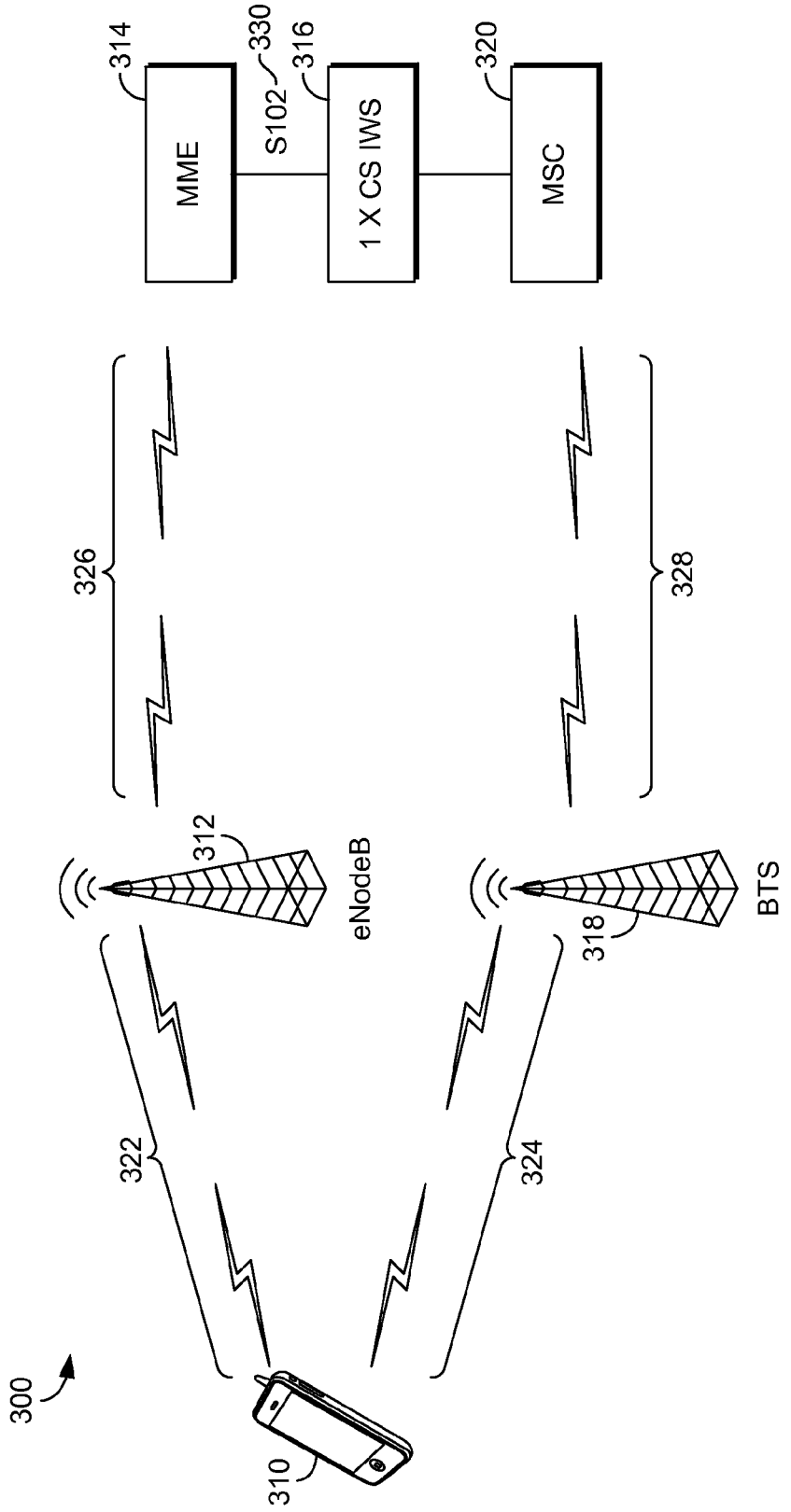

314
MME
330
S102
316
1 X CS IWS
320
MSC
326
328
312
eNodeB
318
BTS
322
324
310
300

FIG. 3.

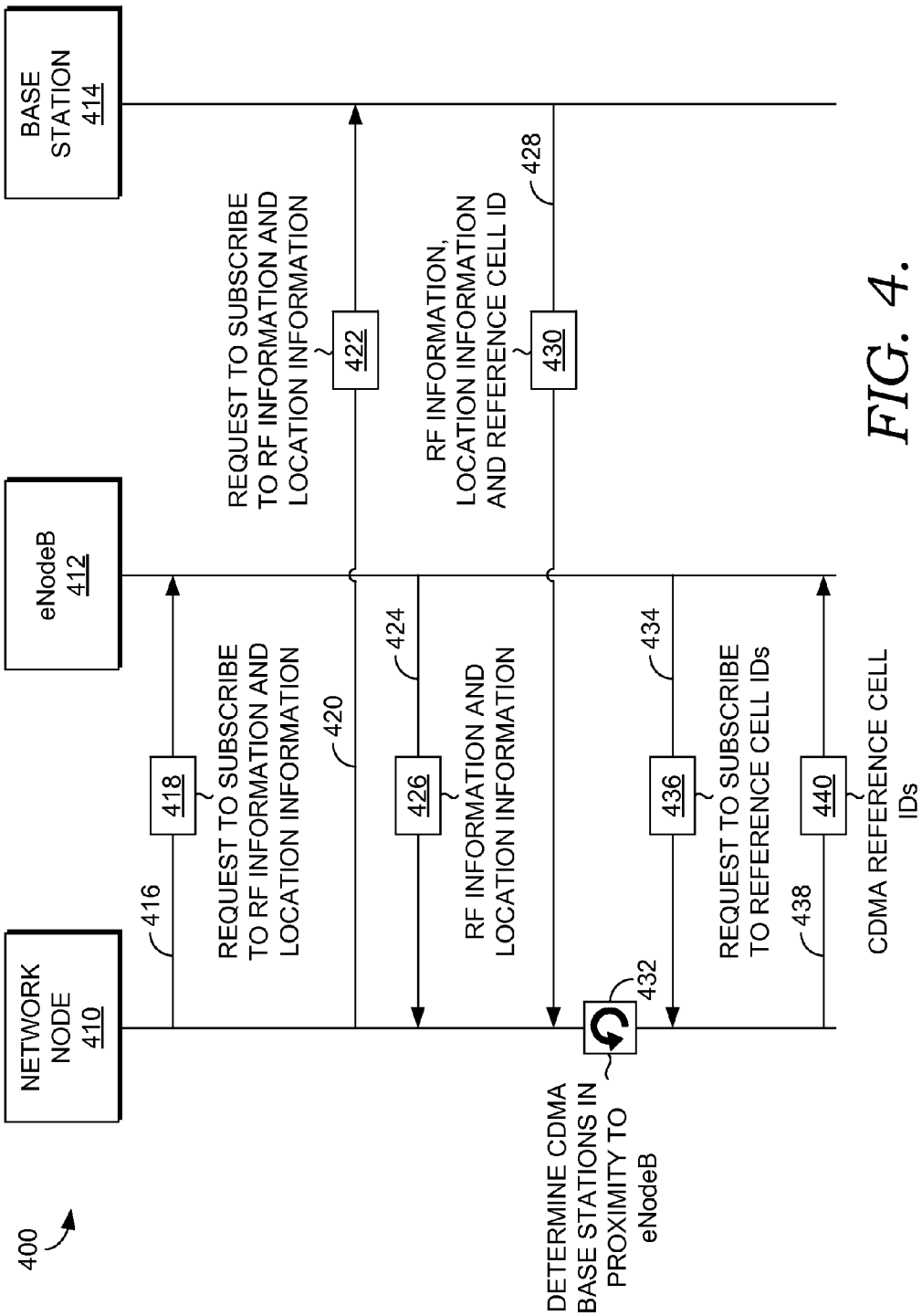

400
NETWORK NODE 410
eNodeB 412
BASE STATION 414
416
418
REQUEST TO SUBSCRIBE TO RF INFORMATION AND LOCATION INFORMATION
420
REQUEST TO SUBSCRIBE TO RF INFORMATION AND LOCATION INFORMATION
422
424
RF INFORMATION AND LOCATION INFORMATION
426
RF INFORMATION, LOCATION INFORMATION AND REFERENCE CELL ID
428
430
DETERMINE CDMA BASE STATIONS IN PROXIMITY TO eNodeB
432
434
REQUEST TO SUBSCRIBE TO REFERENCE CELL IDs
436
438
CDMA REFERENCE CELL IDs
440

FIG. 4.

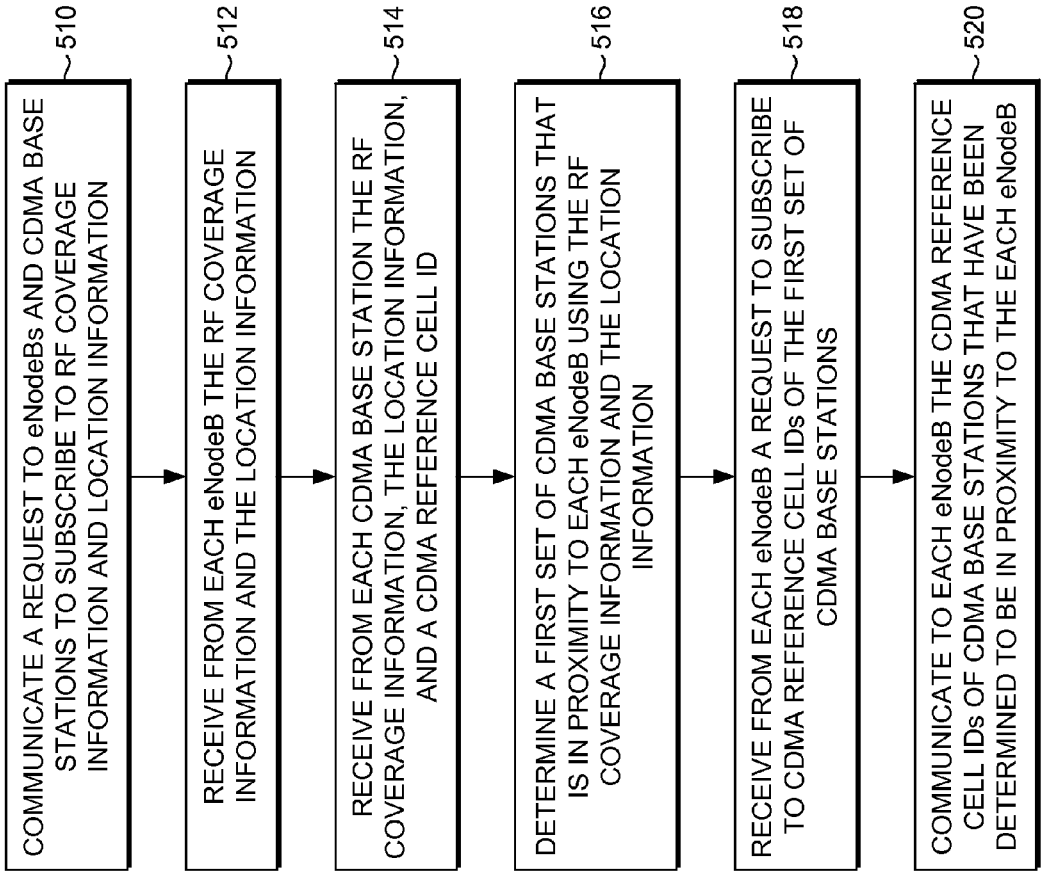

500
510
COMMUNICATE A REQUEST TO eNodeBs AND CDMA BASE STATIONS TO SUBSCRIBE TO RF COVERAGE INFORMATION AND LOCATION INFORMATION
512
RECEIVE FROM EACH eNodeB THE RF COVERAGE INFORMATION AND THE LOCATION INFORMATION
514
RECEIVE FROM EACH CDMA BASE STATION THE RF COVERAGE INFORMATION, THE LOCATION INFORMATION, AND A CDMA REFERENCE CELL ID
516
DETERMINE A FIRST SET OF CDMA BASE STATIONS THAT IS IN PROXIMITY TO EACH eNodeB USING THE RF COVERAGE INFORMATION AND THE LOCATION INFORMATION
518
RECEIVE FROM EACH eNodeB A REQUEST TO SUBSCRIBE TO CDMA REFERENCE CELL IDs OF THE FIRST SET OF CDMA BASE STATIONS
520
COMMUNICATE TO EACH eNodeB THE CDMA REFERENCE CELL IDs OF CDMA BASE STATIONS THAT HAVE BEEN DETERMINED TO BE IN PROXIMITY TO THE EACH eNodeB

FIG. 5.

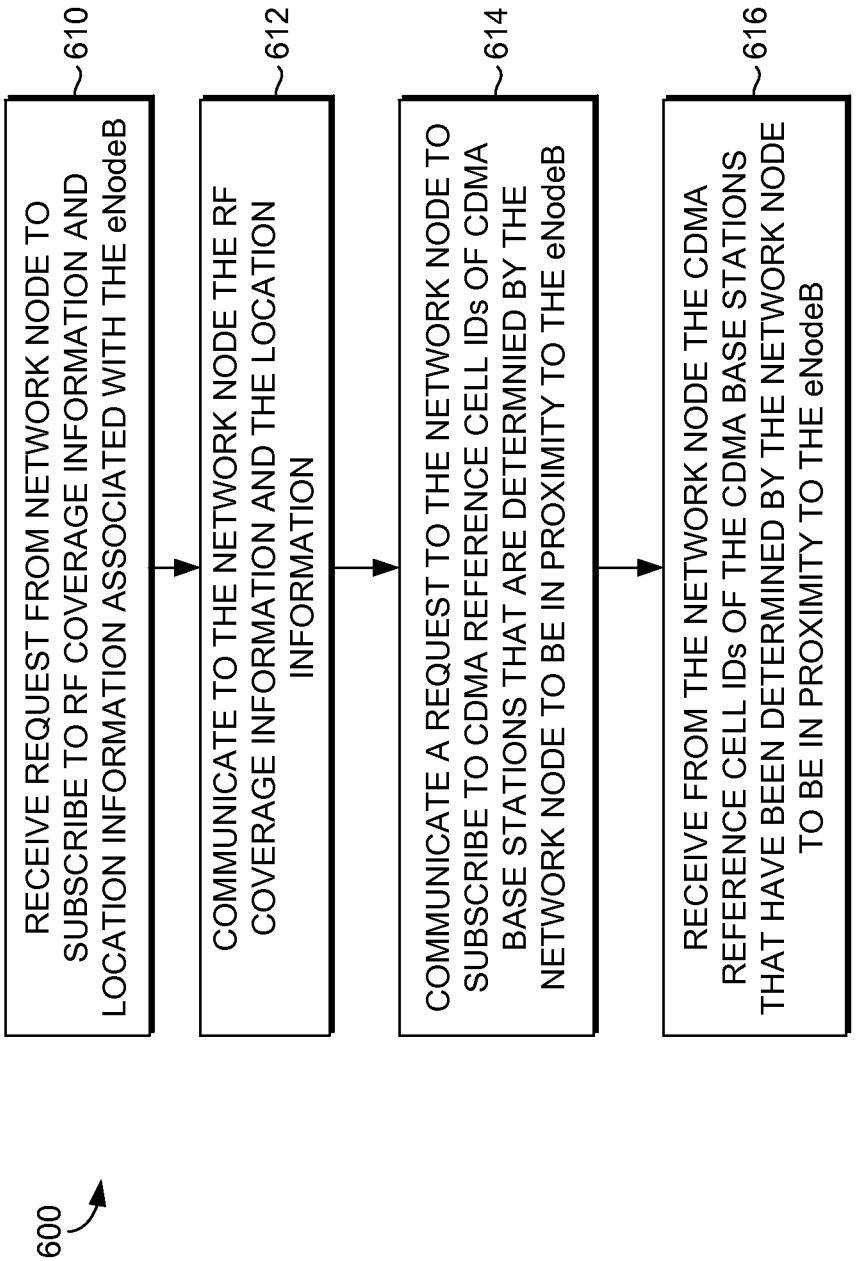

600
610
RECEIVE REQUEST FROM NETWORK NODE TO SUBSCRIBE TO RF COVERAGE INFORMATION AND LOCATION INFORMATION ASSOCIATED WITH THE eNodeB
612
COMMUNICATE TO THE NETWORK NODE THE RF COVERAGE INFORMATION AND THE LOCATION INFORMATION
614
COMMUNICATE A REQUEST TO THE NETWORK NODE TO SUBSCRIBE TO CDMA REFERENCE CELL IDs OF CDMA BASE STATIONS THAT ARE DETERMNIED BY THE NETWORK NODE TO BE IN PROXIMITY TO THE eNodeB
616
RECEIVE FROM THE NETWORK NODE THE CDMA REFERENCE CELL IDs OF THE CDMA BASE STATIONS THAT HAVE BEEN DETERMINED BY THE NETWORK NODE TO BE IN PROXIMITY TO THE eNodeB

FIG. 6.

MANAGEMENT OF CDMA REFERENCE CELL IDENTIFIERS IN AN LTE NETWORK

SUMMARY

A high level overview of various aspects of the invention is provided here for that reason, to provide an overview of the disclosure and to introduce a selection of concepts that are further described below in the detailed-description section below. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in isolation to determine the scope of the claimed subject matter.

In brief, and at a high level, this disclosure describes, among other things, computer-readable media, methods, and systems, for managing CDMA reference cell identifiers (IDs) in an LTE network using a signaling communications protocol such as the Session Initiation Protocol (SIP). A network node communicates a request to eNodeBs and CDMA base stations within the network to subscribe to radio-frequency (RF) coverage information and location information associated with each of the eNodeBs and each of the CDMA base stations. Upon receiving the network node request, the eNodeBs and the CDMA base stations communicate their RF coverage information and their location information to the network node. Additionally, each CDMA base station communicates a CDMA reference cell ID associated with the particular CDMA base station. The network node then determines CDMA base stations that are in proximity to each of the eNodeBs. This determination is based on the RF coverage information and the location information received from the eNodeBs and the CDMA base stations. The network node receives a request from each eNodeB to subscribe to CDMA reference cell IDs of those CDMA base stations that have been determined by the network node to be in proximity to the respective eNodeB. The network node communicates to each eNodeB the CDMA reference cell IDs of those CDMA base stations that have been determined by the network node to be in proximity to the respective eNodeB.

BRIEF DESCRIPTION OF THE DRAWINGS

Illustrative embodiments of the present invention are described in detail below with reference to the attached drawing figures, and wherein:

FIG. **1** depicts an exemplary mobile device according to an embodiment of the technology;

FIG. **2** depicts an exemplary LTE-communications-network-environment suitable for practicing an embodiment of the technology;

FIG. **3** depicts an illustrative relationship between a user equipment, an eNodeB, a base transceiver station, and one or more network nodes suitable for practicing an embodiment of the technology;

FIG. **4** depicts a process-flow diagram illustrating an exemplary method of managing CDMA reference cell IDs in an LTE network according to an embodiment of the technology;

FIG. **5** depicts an illustrative flow diagram of an exemplary method of a network node managing CDMA reference cells IDs in an LTE network according to an embodiment of the technology; and

FIG. **6** depicts an illustrative flow diagram of an exemplary method of automatically and without human intervention populating an eNodeB with CDMA reference cell IDs of CDMA base stations that are in proximity to the eNodeB according to an embodiment of the technology.

DETAILED DESCRIPTION

The subject matter of select embodiments of the present invention is described with specificity herein to meet statutory requirements. But the description itself is not intended to define what we regard as our invention, which is what the claims do. The claimed subject matter might be embodied in other ways to include different steps or combinations of steps similar to the ones described in this document, in conjunction with other present or future technologies. Terms should not be interpreted as implying any particular order among or between various steps herein disclosed unless and except when the order of individual steps is explicitly described.

Throughout this disclosure, several acronyms and shorthand notations are used to aid the understanding of certain concepts pertaining to the associated system and services. These acronyms and shorthand notations are intended to help provide an easy methodology of communicating the ideas expressed herein and are not meant to limit the scope of the present invention. The following is a list of these acronyms:

BTS Base Transceiver Station
CDMA Code Division Multiple Access
1XCS IWS Circuit-Switched Inter-Working Solution
eCSFB Enhanced Circuit-Switched Fallback
eNodeB Evolved Node B
GIS Geographic Information System
2GPP 2nd Generation Partnership Project
3GPP 3rd Generation Partnership Project
GPRS General Packet Radio Service
GSM Global System for Mobile Communications
HSS Home Subscriber Server
LTE Long-Term Evolution
MME Mobile Management Entity
MSC Mobile Switching Center
PGW Packet Data Node Gateway
RF Radio-Frequency
SGW Serving Gateway
SIP Session Initiation Protocol
SMS Short Messaging Service
TDMA Time Division Multiple Access
UE User Equipment
WCDMA Wideband Code Division Multiple Access
WiMAX Worldwide Interoperability for Microwave Access

Further, various technical terms are used throughout this description. An illustrative resource that fleshes out various aspects of these terms can be found in Newton's Telecom Dictionary, 27th Edition (2012).

Embodiments of the present invention may be embodied as, among other things, a method, system, or set of instructions embodied on one or more non-transitory computer-readable or computer-storage media. Computer-readable media comprises physical storage devices and include both volatile and nonvolatile media, removable and nonremovable media, and contemplates media readable by a database, a switch, and various other network devices. By way of example, and not limitation, computer-readable media comprise media implemented in any method or technology for storing information. Examples of stored information include computer-useable instructions, data structures, program modules, and other data representations. Media examples include, but are not limited to computer-storage media such as information-delivery media, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital ver-

satile discs (DVD), holographic media or other optical disc storage, magnetic cassettes, magnetic tape, magnetic disk storage, and other magnetic storage devices. These technologies can store data momentarily, temporarily, or permanently.

Examples of the present invention are directed toward methods, systems, and computer-readable medium for managing CDMA reference cell IDs in an LTE network using a signaling communications protocol such as SIP. A network node subscribes to RF coverage information and location information of eNodeBs and CDMA base stations within the network. After receiving this information from the eNodeBs and the CDMA base stations, the network node uses the information to determine CDMA base stations that are in proximity to each eNodeB. The eNodeBs in the network subscribe to CDMA reference cell IDs of those CDMA base stations that have been determined by the network node to be in proximity to the respective eNodeB. After receiving the CDMA reference cell IDs from the network node, each eNodeB utilizes the received information to select a CDMA base station to utilize when a network customer's UE requires circuit-switched services.

Accordingly, in a first aspect, a network node communicates a request to eNodeBs and CDMA base stations within the network to subscribe to radio-frequency (RF) coverage information and location information associated with each of the eNodeBs and each of the CDMA base stations. Upon receiving the network node request, the eNodeBs and the CDMA base stations communicate their RF coverage information and their location information to the network node. Additionally, the CDMA base stations communicate a CDMA reference cell ID associated with the particular CDMA base station. The network node then determines CDMA base stations that are in proximity to each of the eNodeBs. This determination is based on the RF coverage information and the location information received from the eNodeBs and the CDMA base stations. The network node receives a request from each eNodeB to subscribe to CDMA reference cell IDs of those CDMA base stations that have been determined by the network node to be in proximity to the respective eNodeB. The network node communicates to each eNodeB the CDMA reference cell IDs of those CDMA base stations that have been determined by the network node to be in proximity to the respective eNodeB.

In a second aspect, an eNodeB receives a request from a network node to subscribe to RF coverage information and location information associated with the eNodeB. The eNodeB communicates the RF coverage information and the location information to the network node. As well, the eNodeB communicates a request to the network node to subscribe to CDMA reference cell IDs of CDMA base stations that are determined by the network node to be in proximity to the eNodeB. The eNodeB then receives from the network node the CDMA reference cell IDs of the CDMA base stations that have been determined by the network node to be in proximity to the eNodeB.

In a third aspect, a network node communicates a SIP request to each eNodeB and each CDMA base station within the network to subscribe to RF coverage information and location information associated with each of the eNodeBs and each of the CDMA base stations. The network node receives a SIP response from each of the eNodeBs comprising the RF coverage information and the location information. As well, the network node receives a SIP response from each of the CDMA base stations comprising the RF coverage information, the location information, and a CDMA reference cell ID associated with each of the CDMA base stations. The network node determines for each of the eNodeBs one or more CDMA base stations in proximity to the eNodeB using the RF coverage information and the location information received from the eNodeBs and the CDMA base stations. The network node receives a SIP request from each of the eNodeBs to subscribe to CDMA reference cell IDs of CDMA base stations determined by the network node to be in proximity to each of the respective eNodeBs. The network node communicates a SIP response to each of the eNodeBs comprising the CDMA reference cell IDs of the CDMA base stations determined by the network node to be in proximity to the respective eNodeB.

As way of background, currently in most wireless-telecommunications-networks voice traffic is handled by legacy technologies that support circuit-switching, such as CDMA, GSM, and WCDMA while data traffic is handled by packet-switched technologies such as LTE, if available, and by 2GPP and 3GPP technologies in non-LTE areas. Single radio devices (i.e., single radio UEs) use one radio to handle both data and voice traffic. For these types of devices, enhanced circuit-switched fallback (eCSFB) is one of the solutions used by the network to provide voice services and SMS services to users of LTE when voice and SMS services are not implemented on LTE. eCSFB utilizes an inter-working solution (IWS) to switch a UE from LTE technology to a circuit-switched technology such as CDMA so that circuit-switched voice calls can be served to or by the UE. eCSFB is based on the premise that UEs remain associated with the LTE technology until the UEs require circuit-switched services. Once the circuit-switched services are concluded, the UE is switched back to the LTE technology.

While associated with the LTE technology, a UE may utilize LTE channels associated with one or more eNodeBs for data-based services. In order for a particular eNodeB that is currently carrying the UE to effectuate the transfer of the UE to a circuit-switched technology, the eNodeB must be aware of suitable CDMA base stations or channels in proximity to the eNodeB that are available to carry the UE. Currently, eNodeBs in the network are manually populated with reference cell IDs of CDMA base stations that are in proximity to the eNodeBs. Besides the usual problem of errors that occurs with manual entry of information, this methods also fails to account for additions of CDMA base stations or eNodeBs to the network, changes in location of existing CDMA base stations or eNodeBs (e.g., mobile CDMA base stations and mobile eNodeBs), and/or changes in RF coverage data associated with the eNodeBs and CDMA base stations.

Turning now to FIG. **1**, a block diagram of an illustrative communications device or UE is provided and is referenced generally by the numeral **150**. Although some components are shown in the singular, they may be plural. For example, the communications device **150** might include multiple processors or multiple radios, etc. As illustratively shown, the communications device **150** includes a bus **160** that directly or indirectly couples various components together including memory **162**, a processor **164**, a presentation component **166**, a radio **168**, input/output ports **170**, input/output components **172**, and a power supply **174**.

The memory **162** might take the form of memory components previously described. Thus, further elaboration will not be provided here, only to say that the memory component **162** can include any type of medium that is capable of storing information (e.g., a database). A database can be any collection of records. In one embodiment, the memory **162** includes a set of embodied computer-executable instructions that, when executed, facilitates various aspects disclosed herein. These embodied instructions will variously be referred to as "instructions" or an "application" for short.

The processor **164** might actually be multiple processors that receive instructions and process them accordingly. The presentation component **166** includes the likes of a display, a speaker, as well as other components that can present information (such as a lamp (LED), or even lighted keyboards).

The radio **168** facilitates communication with a wireless-telecommunications-network. Illustrative wireless-telecommunications technologies include CDMA, EvDO, GPRS, TDMA, GSM, WiMax technology, LTE, LTE Advanced and the like. In some embodiments, the radio **168** might also facilitate other types of wireless communications including Wi-Fi®, Bluetooth® communications, GIS communications, and other near-field communications.

The input/output port **170** might take on a variety of forms. Illustrative input/output ports include a USB jack, stereo jack, infrared port, proprietary communications ports, and the like. The input/output components **172** include items such as keyboards, microphones, speakers, touch screens, and any other item usable to directly or indirectly input data into the communications device **150**. Power supply **174** includes items such as batteries, fuel cells, or any other component that can act as a power source to power the communications device **150**.

FIG. **2** depicts an illustrative LTE wireless-telecommunications-network (the "network") that is referenced generally by the numeral **200**. The illustrative network **200** shown in FIG. **2** is merely an example of one suitable LTE networking environment and is not intended to suggest any limitation as to the scope of use or functionality of embodiments of the present invention. Neither should the network **200** be interpreted as having any dependency or requirement related to any single module/component or combination of modules/components illustrated therein. The network **200** depicted in FIG. **2** is simplified for ease of discussion and may include more or less components than those shown in FIG. **2**.

The network **200** includes a UE **210**, an eNodeB **212**, an MME **214**, a HSS **216**, a SGW **218**, a PGW **220**, and the Internet **224**. The MME **214**, HSS **216**, SGW **218**, and PGW **220** may be considered part of the core network **222**. The UE **210** may be the same as the communications device **150** of FIG. **1**. The UE **210** may support multiple technologies such as CDMA, EvDO, TDMA, LTE, and the like. In one aspect, the UE **210** may comprise a single radio device that can carry only one technology at a time (e.g., either LTE or CDMA). A single radio UE stands in contrast to a dual-radio device that has two always-on radios—one for packet-switched LTE data and one for circuit-switched voice.

The UE **210** may subscribe to voice and data services offered by the core network **222**. As such, the UE **210** may be in communication with the core network **222** via the eNodeB **212**. Communication between the UE **210** and the eNodeB **212**, and between the eNodeB **212** and the core network **222**, occurs through one or more wired- or wireless-telecommunications links. The UE **210** may communicate with the eNodeB **212** via a telecommunications link to facilitate attachment of the UE **210** to the eNodeB **212**. Once attached, the UE **210** may also use the telecommunications link to send and/or receive information.

The eNodeB **212** includes hardware and bandwidth(s) of a specified frequency. The hardware includes, for example, the actual radio mast or tower, as well as antennas, transceivers, GPS receivers, electrical power sources, digital signal processors, control electronics, and the like that are associated with the radio tower. The RF spectrum bandwidth may comprise one or more RF channels. Each channel is capable of supporting different types of technology although only one type of technology is supported by a particular RF channel at a time. With respect to this application, the term "channel" refers to an upload spectrum and a download spectrum. The eNodeB **212** carries LTE on one or more of its channels, but it may also carry other technologies on its other channels such as CDMA. Any and all such aspects, and any combination thereof, are contemplated as being within the scope of the invention.

Besides being in communication with the UE **210**, the eNodeB **212** is also in communication with other network nodes such as the MME **214** and the SGW **218**. The MME **214** is a control node in the LTE network **200**. It is responsible for, among other things, UE tracking and paging procedures, authenticating the UE **210**, and acting as the control point for the transfer of the UE **210** between LTE channels and, for example, CDMA channels. The HSS **216** is a central data store that contains user-related and subscription-related information. The HSS **216** is utilized for user authentication and access authorization. The SGW **218** routes and forwards data packets, while the PGW **220** provides connectivity from the UE **210** to external data packet networks (i.e., the Internet **224**) by being the point of exit and entry of data traffic for the UE **210**. As mentioned, the network **200** may include additional components other than those shown. Further, the components shown in FIG. **2** may carry out additional functions besides those described. The discussion of the network **200** is meant to illustrative only and is provided as an aid in understanding embodiments of the invention.

FIG. **3** depicts an illustrative network relationship between a UE **310**, an eNodeB **312**, a base transceiver station (BTS) **318**, and one or more network nodes including an MME **314**, a 1XCS IWS **316**, and a MSC **320**. The illustrative network relationship is referenced generally by the numeral **300**. The illustrative relationship **300** shown in FIG. **3** is merely an example of one suitable network relationship and is not intended to suggest any limitation as to the scope of use or functionality of embodiments of the present invention. Neither should the network relationship **300** be interpreted as having any dependency or requirement related to any single module/component or combination of modules/components illustrated therein. The network relationship **300** depicted in FIG. **3** is simplified for ease of discussion and may include more or less components than those shown in FIG. **3**.

The UE **310** may be the same as the UE **210** of FIG. **2** and/or the communications device **150** of FIG. **1**. Likewise, the eNodeB **312** may be the same as the eNodeB **212** of FIG. **2**. The BTS **318** carries one or more circuit-switched technologies such as CDMA. As used throughout this specification, the BTS **318** may otherwise be known as a CDMA base station. The BTS **318** includes hardware and bandwidth(s) of a specified frequency. The RF spectrum bandwidth may comprise one or more RF channels. Each channel is capable of supporting different types of technology although only one type of technology is supported by a particular RF channel at a time. The channels associated with the BTS **318** carry circuit-switched technologies such as CDMA. In one aspect, the eNodeB **312** and the BTS **318** may comprise the same base station—a base station configured to carry both LTE technology and circuit-switched technologies. The UE **310** communicates with the eNodeB **312** and the BTS **318** through wireless-telecommunications links **322** and **324** respectively.

As discussed above with respect to FIG. **2**, the eNodeB **312** communicates with the MME **314** through a wired- or wireless-telecommunications link **326** (the MME **314** may be the same as the MME **214** of FIG. **2**). The MME **314** serves the UE **310** during LTE access. In one instance, the eNodeB **312** communicates CDMA reference cell IDs to the MME **314** via

the telecommunications link **326**. The MSC serves the UE **310** voice or SMS services either directly by the BTS **318** via telecommunications link **328** when the UE **310** is not on the LTE network, or by the eNodeB **312** via the 1XCS IWS **316** (hereinafter known as the "IWS **316**") when the UE **310** is on the LTE network. As shown, the MME **314** is indirectly connected to the MSC **320** through the IWS **316**. The IWS **316** thus acts as a bridge between the LTE-specific MME **314** and the circuit-switched-specific MSC **320**. The MME **314** selects the IWS **316** node based on the reference cell ID information provided by the eNodeB **312**. The S**102** interface **330** between the MME **314** and the IWS **316** enables the UE **310** to utilize both packet-switched services (e.g., data services) and circuit-switched services (e.g., voice and SMS services) while on the LTE network.

Turning now to FIG. **4**, a process-flow diagram, referenced generally by the numeral **400**, is depicted illustrating an exemplary method **400** of managing CDMA reference cell IDs in an LTE network. FIG. **4** includes a network node **410**, an eNodeB **412**, and a CDMA base station **414**. The eNodeB **412** and the CDMA base station **414** may correspond to the eNodeB **312** and the BTS **318** of FIG. **3** respectively. Although only one eNodeB and one CDMA base station are shown in FIG. **4**, it is contemplated that there are multiple eNodeBs and multiple CDMA base stations. The network node **410** comprises a new network node (e.g., a network node that is not currently part of the LTE system architecture). The network node **410** may be thought of as a CDMA/LTE presence awareness node.

At a step **416**, the network node **410** communicates to the eNodeB **412** a request **418** to subscribe to RF coverage information and location information associated with the eNodeB **412**. The subscribe request **418** may be made using a signaling communications protocol such as SIP (RFC 3265 Session Initiation Protocol (SIP)-Specific Event Notification). SIP has elements similar to the HTTP request/response transaction model. For example, each entity in the SIP network is identified by a uniform resource identifier (URI). The SIP subscribe request originates from a first entity and includes an event type and a request-URI, indicating where the request should be sent. The event type describes the type of information being subscribed to by the first entity. A SIP notify response is returned by those entities that received the SIP request and includes the information corresponding to the event type as well as information identifying the entity in the "From" header of the response. Thus, with respect to the subscribe request **418**, the event type comprises "loc-RFCov," which corresponds to "Location and RF Coverage" information.

At a step **420**, the network node **410** communicates to the base station **414** a request **422** to subscribe to RF coverage information and location information associated with the base station **414**. Again, the subscribe request **422** comprises a SIP subscribe request with an event type "loc-RFCov."

At a step **424**, the eNodeB **412** communicates a response **426** to the network node **410**; the response **426** includes the location information and the RF coverage information associated with the eNodeB **412**. The response **426** may comprise a SIP notify response as outlined above. The location information may comprise GPS coordinates associated with the eNodeB **412**. Other types of location information known in the art may also be utilized. The RF coverage information associated with the eNodeB **412** may comprise the RF propagation model used by the eNodeB **412**, the RF coverage radius of the eNodeB **412**, and the like.

At a step **428**, the base station **414** communicates a response **430** to the network node **410**. The response **430** may comprise a SIP notify response and include RF coverage information and location information associated with the base station **414**. Like above, the RF coverage information may comprise the RF propagation model used by the base station **414**, the RF coverage radius associated with the base station **414**, and the like. The location information may comprise GPS coordinates associated with the base station **414** as well as other types of localization information known in the art. The header of the response **430** also includes the reference cell ID associated with the base station **414**.

The responses **426** and **430** will be communicated to the network node **410** each time the location information and/or the RF coverage information associated with the eNodeB **412** and/or the base station **414** changes. There are several instances where this may occur. For example, the eNodeB **412** and/or the base station **414** may be mobile. Thus, every time the eNodeB **412** and/or the base station **414** changes location, the eNodeB **412** and/or the base station **414** communicates updated location information to the network node **410**. In another example, in response to RF interference from a neighboring base station, the eNodeB **412** and/or the base station **414** may alter its RF propagation model to minimize the interference. The updated RF coverage information is then communicated to the network node **410**. Any and all such aspects, and any variation thereof, are contemplated as being within the scope of the invention.

At a step **432**, the network node **410** processes the RF coverage information and location information received from the eNodeB **412** and the base station **414** to determine if the CDMA base station **414** is in proximity to the eNodeB **412**. As explained above, although only one eNodeB **412** and one base station **414** are shown in FIG. **4**, it is contemplated that the network node **410** receives multiple sets of location and RF coverage information from the base stations and the eNodeBs in the network. The network node **410** processes all of this information to determine CDMA base stations that are in proximity to each of the eNodeBs. A CDMA base station is determined to be in proximity to a particular eNodeB when the RF coverage radius of the CDMA base station overlaps with the RF coverage radius of the particular eNodeB, and the GPS coordinates of the CDMA base station and the eNodeB indicate that they are in geographic proximity to each other. After determining CDMA base stations that are in proximity to each of the eNodeBs, the network node **410** stores this information in a data store. The network node **410** may make a new determination each time updated RF coverage information and/or location information is received from the eNodeB **412** and/or the base station **414**.

At a step **434**, the eNodeB **412** communicates to the network node **410** a request **436** to subscribe to CDMA reference cell IDs of CDMA base stations that have been determined by the network node **410** to be in proximity to the eNodeB **412**. The subscribe request **436** may comprise a SIP subscribe request having an event type "CRCI," which corresponds to "CDMA reference cell ID." At a step **438**, the network node **410** communicates a response **440** to the eNodeB **412** that includes the CDMA reference cell IDs of those CDMA base stations that have been determined by the network node **410** to be in proximity to the eNodeB **412**.

Every time the network node **410** makes a new determination of CDMA base stations in proximity to the eNodeB **412** (e.g., in response to updated RF coverage information and/or location information), the network node **410** communicates the response **440** to the eNodeB **412** with the updated set of CDMA reference cell IDs.

The result of the method outlined in FIG. **4** is that the eNodeB **412** is automatically and without human intervention

populated with CDMA reference cell IDs of CDMA base stations that have been determined by the network node **410** to be in proximity to the eNodeB **412**. The method **400** is carried out by the network node **410** for each eNodeB in the network. When a UE associated with the eNodeB **412** requires circuit-switched voice or SMS services, the eNodeB **412** will communicate the corresponding fallback CDMA reference cell ID to the UE and to the MME as outlined above, and the MME selects an IWS to use for eCSFB based on the CDMA reference cell ID.

Turning now to FIG. **5**, a flow diagram is depicted of an exemplary method **500** of a network node, such as the network node **410** of FIG. **4**, managing CDMA reference cells IDs in an LTE network. At a step **510**, the network node communicates a request to each eNodeB and each CDMA base station within the network. The request comprises a request to subscribe to RF coverage information and location information associated with each of the eNodeBs and each of the CDMA base stations. The subscribe request may be executed using SIP, and the SIP subscribe request may include an event type of "loc-RFCov," which corresponds to "Location and RF Coverage." The SIP subscribe request remains in effect until it expires according to standard SIP specifications. At the time of expiration, the SIP request may be re-sent from the network node to the eNodeBs and the CDMA base stations.

At a step **512**, the network node receives from each of the eNodeBs the RF coverage information and the location information. The information may be received in the form of a SIP notify response. The RF coverage information comprises a RF propagation model utilized by the particular eNodeB and a RF coverage radius associated with the particular eNodeB. The location information comprises GPS coordinates associated with the particular eNodeB. At a step **514**, the network node receives from each of the CDMA base stations the RF coverage information and the location information. The information may be received in the form of a SIP notify response. Each response also includes the reference cell ID of the particular base station. Like above, the RF coverage information comprises a RF propagation model utilized by the particular CDMA base station and a RF coverage radius associated with the base station, and the location information comprises GPS coordinates associated with the particular base station. The eNodeBs and the CDMA base stations within the network communicate responses containing RF coverage information and location information to the network node each time the information changes or is updated.

At a step **516**, the network node determines CDMA base stations that are in proximity to each of the eNodeBs using the RF coverage information and the location information received from the eNodeBs and the CDMA base stations. A CDMA base station may be determined to be in proximity to a particular eNodeB when the RF coverage radiuses overlap and when the GPS coordinates indicate that they are in geographic proximity to each other. The network node may store this information along with the RF coverage information and the location information in association with a data store.

At a step **518**, the network node receives from each of the eNodeBs in the network a request to subscribe to CDMA reference cell IDs of those CDMA base stations that have been determined by the network node to be in proximity to the particular eNodeB. The subscribe request may comprise a SIP subscribe request having the event type "CRCI," which corresponds to "CDMA Reference Cell ID." The SIP subscribe request received from eNodeBs remains in effect until it expires according to standard SIP specifications. At the time of expiration, the SIP request may be re-sent from each of the eNodeBs.

At a step **520**, the network node communicates to each of the eNodeBs the CDMA reference cell IDs of those CDMA base stations that have been determined by the network node to be in proximity to the particular eNodeB. The CDMA reference cell IDs are used by the eNodeBs to determine a CDMA base station to utilize when a network customer's UE requires circuit-switched services such as voice and SMS services.

Turning now to FIG. **6**, a flow diagram is depicted of an exemplary method **600** of automatically and without human intervention populating an eNodeB with CDMA reference cell IDs of CDMA base stations that are proximity to the eNodeB. At a step **610**, the eNodeB receives a subscribe request from a network node to subscribe to RF coverage information and location information associated with the eNodeB. The subscribe request may be in the form of a SIP subscribe request having an event type of "loc-RFCov."

At a step **612**, the eNodeB communicates to the network node the RF coverage information and the location information. This may be in the form of a SIP notify response. The eNodeB communicates this information to the network node each time the location information and/or the RF coverage information changes.

At a step **614**, the eNodeB communicates a subscribe request to the network node subscribing to CDMA reference cell IDs of CDMA base stations that have been determined by the network node to be in proximity to the eNodeB. The subscribe request may comprise a SIP subscribe request having an event type "CRCI." The network node may base its determination of CDMA base stations in proximity to the eNodeB on the location information and RF coverage information received from the eNodeB along with location information and RF coverage information received from other eNodeBs and CDMA base stations in the network. The subscribe request communicated at step **514** remains in effect until it expires based on standard SIP specifications. At this time, the eNodeB may communicate a new subscribe request having the event type "CRCI."

At a step **616**, the eNodeB receives from the network node CDMA reference cell IDs of those CDMA base stations that have been determined by the network node to be in proximity to the eNodeB. The eNodeB utilizes these reference cell IDs to determine a CDMA base station to fall back to when a UE associated with the eNodeB requires circuit-switched services. The eNodeB may receive updated CDMA reference cell IDs in response to a change in RF coverage information and/or location information of the eNodeB or in response to changes in RF coverage information and/or location information of CDMA base stations in the network.

Many different arrangements of the various components depicted, as well as components not shown, are possible without departing from the scope of the claims below. Embodiments of our technology have been described with the intent to be illustrative rather than restrictive. Alternative embodiments will become apparent to readers of this disclosure after and because of reading it. Alternative means of implementing the aforementioned can be completed without departing from the scope of the claims below. Certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations and are contemplated within the scope of the claims.

What is claimed is:

1. One or more non-transitory computer-readable media having computer-executable instructions embodied thereon

that, when executed by a network node in a long-term-evolution (LTE) network (the "network"), cause the network node to perform a method of using Session Initiation Protocol (SIP) to manage code division multiple access (CDMA) reference cell identifiers (IDs) in the network, the method comprising:

at the network node in the network:

communicating a SIP request to each eNodeB and each CDMA base station in the network to subscribe to radio-frequency (RF) coverage information and location information associated with the each eNodeB and the each CDMA base station;

receiving a SIP response from the each eNodeB in the network comprising the RF coverage information and the location information;

receiving a SIP response from the each CDMA base station in the network comprising the RF coverage information, the location information, and a CDMA reference cell ID associated with the each CDMA base station;

for the each eNodeB, determining a first set of CDMA base stations that is in proximity to the each eNodeB using the RF coverage information and the location information received from the each eNodeB and the each CDMA base station;

receiving from the each eNodeB a SIP request to subscribe to CDMA reference cell IDs of the first set of CDMA base stations that is determined by the network node to be in proximity to the each of the eNodeBs; and

communicating a SIP response to the each eNodeB comprising the CDMA reference cell IDs of the first set of CDMA base stations that is determined by the network node to be in proximity to the each eNodeBs, wherein the CDMA reference cell IDs are utilized by the each eNodeB to determine a CDMA base station within the first set of CDMA base stations to utilize when a network customer's user equipment (UE) associated with the each eNodeB requires voice or SMS services.

2. The media of claim **1**, wherein the RF coverage information comprises a coverage radius associated with the each eNodeB and the each CDMA base station and a RF propagation model associated with the each eNodeB and the each CDMA base station.

3. The media of claim **2**, wherein the location information comprises GPS coordinates associated with the each eNodeB and the each CDMA base station.

4. The media of claim **3**, wherein the first set of CDMA base stations is determined to be in proximity to the each eNodeB when the RF coverage radius of the first set of CDMA base stations overlaps with the RF coverage radius of the each eNodeB, and the GPS coordinates of the first set of CDMA base stations indicate that the CDMA base stations in the first set of CDMA base stations are in geographic proximity to the each eNodeB.

5. The media of claim **1**, wherein the UE comprises a single radio UE.

6. The media of claim **1**, further comprising:

receiving from at least a portion of the eNodeBs at least one of an updated set of RF coverage information or an updated set of location information;

for each eNodeB of the at least the portion of eNodeBs, determining a second set of CDMA base stations that is in proximity to the each eNodeB using the updated set of RF coverage information, the updated set of location information, the existing CDMA base station RF coverage information, and the existing CDMA base station location information; and

communicating to the each eNode B of the at least the portion of the eNodeBs the CDMA reference cell IDs of the second set of CDMA base stations that is determined by the network node to be in proximity to the each eNodeB of the at least the portion of the eNodeBs.

7. The media of claim **1**, further comprising:

receiving from at least a portion of the CDMA base stations at least one of an updated set of RF coverage information or an updated set of location information;

for each of the eNodeBs in the network, determining a second set of CDMA base stations that is in proximity to the each eNodeB using the updated set of RF coverage information, the updated set of location information, the existing eNodeB RF coverage information, and the existing eNodeB location information; and

communicating to the each of the eNodeBs the CDMA reference cell IDs of the second set of CDMA base stations that is determined by the network node to be in proximity to the each of the eNodeBs.

8. One or more non-transitory computer-readable media having computer-executable instructions embodied thereon that, when executed by a computing device associated with an eNodeB in a long-term-evolution (LTE) network (the "network"), cause the computing device to perform a method of automatically and without human intervention populating the eNodeB with code-division-multiple-access (CDMA) reference cell identifiers (IDs) of CDMA base stations that are in proximity to the eNodeB, the method comprising:

at the eNodeB:

receiving a Session Initiation Protocol (SIP) request from a network node in the network to subscribe to radio-frequency (RF) coverage information and location information associated with the eNodeB;

communicating to the network node a SIP response comprising the RF coverage information and the location information;

communicating a SIP request to the network node to subscribe to a set of CDMA reference cell IDs of CDMA base stations that are determined by the network node to be in proximity to the eNodeB; and

receiving a SIP response from the network node comprising the set of CDMA reference cell IDs of the CDMA base stations that have been determined by the network node to be in proximity to the eNodeB, wherein the set of CDMA reference cell IDs are useable by the eNodeB to determine a CDMA base station to utilize when a user equipment (UE) associated with the eNodeB requires circuit-switched services.

9. The media of claim **8**, further comprising:

receiving an indication that the UE associated with the eNodeB requires access to circuit-switched services; and

communicating to the network at least one CDMA reference cell ID of the set of CDMA reference cell IDs, wherein the network utilizes the at least one CDMA reference cell ID to provide the UE access to the circuit-switched services.

10. The media of claim **8**, further comprising:

receiving an indication that at least one of the RF coverage information or the location information associated with the eNodeB has been modified;

communicating to the network node the at least one of the modified RF coverage information or the modified location information; and

receiving from the network node an updated set of CDMA reference cell IDs of CDMA base stations that have been determined by the network node to be in proximity to the eNodeB.

11. One or more non-transitory computer-readable media having computer-executable instructions embodied thereon that, when executed by a network node in a long-term-evolution (LTE) network (the "network"), cause the network node to perform a method of using Session Initiation Protocol (SIP) to manage code division multiple access (CDMA) reference cell identifiers (IDs) in the network:

at the network node in the network:

communicating a SIP request to each eNodeB and each CDMA base station within the network to subscribe to radio-frequency (RF) coverage information and location information associated with the each eNodeB and the each CDMA base station;

receiving a SIP response from the each eNodeB in the network comprising the RF coverage information and the location information;

receiving a SIP response from the each CDMA base station in the network comprising the RF coverage information, the location information, and a CDMA reference cell ID associated with the each CDMA base station;

determining for the each eNodeB in the network one or more CDMA base stations in proximity to the each eNodeB using the RF coverage information and the location information received from the each CDMA base station and the each eNodeB;

receiving a SIP request from the each of the eNodeBs in the network to subscribe to CDMA reference cell IDs of CDMA base stations determined by the network node to be in proximity to the each eNodeB; and

communicating a SIP response to the each of the eNodeBs comprising CDMA reference cell IDs of the CDMA base stations determined by the network node to be in proximity to the each eNodeB, wherein the CDMA reference cell IDs are utilized by the each eNodeB to determine a CDMA base station to utilize when a network customer's user equipment (UE) associated with the each eNodeB requires circuit-switched services.

12. The media of claim **11**, wherein the SIP request to subscribe to RF coverage information and location information associated with the each eNodeB and the each CDMA base stations includes an event type comprising "loc-RF-Cov".

13. The media of claim **11**, wherein the CDMA reference cell ID received from the each CDMA base station is included in a "From" header of the SIP response.

14. The media of claim **11**, wherein the SIP request received from the each of the eNodeBs to subscribe to CDMA reference cell IDs of CDMA base stations determined by the network node to be in proximity to the each eNodeB includes an event type comprising "CRCI".

15. The media of claim **11**, wherein the RF coverage information comprises a RF propagation model and a RF coverage radius.

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